

Biofuels Research and Development to Reduce Reliance on Imported Petroleum
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Written Statement of Dr. Dan E. Arvizu
Director, National Renewable Energy Laboratory
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Introductory Remarks

Mr. Chairman, thank you for this opportunity to discuss biofuels research and development – as a way to diversify our nation’s crucial supply of transportation fuels and reduce our reliance on imported petroleum. I am the director of the National Renewable Energy Laboratory, in Golden, Colorado. NREL is the U.S. Department of Energy’s primary laboratory for research and development of renewable energy and energy efficiency technologies, and is home to the National Bioenergy Center.

The committee is to be commended for the comprehensive, inclusive nature of the discussion it is initiating here today. For it is only through such a thorough examination of *all* the issues and needs associated with this profound undertaking that we can ensure our work will have the real-world results those of us gathered here so intently desire, and our nation so vitally needs.

One of the most striking realizations one has when considering the enormity of the task at hand, is that while technology research is absolutely essential – so is biomass resource development and utilization, ensuring the integrity of the fuel supply, vehicle and transportation system integration with fuels, impacts on water and the environment, infrastructure requirements ... these are just a few of the many factors at play.

What we need first and foremost, then, is a comprehensive, integrated program for biofuels development that takes into account all critical factors individually and collectively. To do this, I propose a “National Needs Assessment” be undertaken in the near future. This comprehensive study and report would analyze our long-term goals, and take into account the full range of needs – on both the demand and supply side – that will be required to meet our goals.

Secondly, we need to look beyond the research we are conducting today, and carefully plan for and embark upon the broadest portfolio for future development of all biofuels that may prove valuable to our nation. Our work with ethanol producers, cellulosic ethanol pioneers, chemical and biotech firms and major oil companies has clearly demonstrated that a multi-faceted approach to biofuels development will most benefit the emerging industry, and the nation, over the longer term.

This “portfolio” of fuels would evolve over time to take advantage of new resources, technology breakthroughs and market opportunities. We first need to establish a rich and diverse biofuels portfolio, then plan our research efforts to support its realization.

All this must be done in close collaboration with industry. NREL manages its R&D portfolio with a strong reliance on partnerships, through which we work hand-in-hand with industry, to identify and produce as an end result those technologies most relevant to market needs.

Thirdly, we must make necessary new investments in our research capabilities – because having adequate research facilities is essential to all other R&D goals. The nation’s world-class laboratory system and its leading academic institutions must be re-tooled, and funded at an adequate level, so we have the necessary capabilities to see this vital mission to its successful conclusion.

As we plan for these critical new investments in research capabilities, we should do so in way that builds upon a primary research center, and draws upon important regional research and educational capabilities around the country. This is an especially efficient model for biofuels research, as it is expected the biofuels industry will grow up to look different in various regions of the U.S., as each state naturally builds upon its own unique blend of resources and opportunities.

Today, NREL, as home to the Department of Energy’s National Bioenergy Center, has the capabilities to lead the nation toward a biofuels future. We are confident that the current focus on developing technology to quickly enable the development of a cellulosic ethanol industry in this country is the correct and prudent first step.

History has shown us, however, that it is only by setting out on the broadest research course that we can guarantee we will arrive with the best set of eventual technologies from which industry and the marketplace can chose, and to ensuring that U.S. industry maintains its leadership role amid global competition.

Message Points for Q&A

History -- NREL Led Way Through History of Biofuels Research

The history of U.S. development of biofuels is deeply intertwined with the history of NREL:

- NREL began pioneering biofuels research nearly 30 years ago.
- NREL's research on cellulosic ethanol led the evolution of today's integrated biorefinery concept, which employs a chemical pre-treatment and hydrolysis of hemicellulose, enzymatic hydrolysis of cellulose, fermentation of all the sugars and thermochemical conversion of the lignin residue.
- NREL's accomplishments in the field of cellulosic ethanol include:
 - Development of a patented dilute acid pretreatment technology
 - Published a detailed process design for biochemical conversion in 2002 and for thermochemical conversion in 2007 on how to achieve \$1.07 per gallon, that has become the "gold standard;"
 - Development of one of the leading biological organisms for co-fermenting C5 and C6 sugars;
 - 20-fold decrease in the cost of enzymes with Novozyme & Genencor
 - Support to many of the leading companies in this field (DuPont, Broin, Abengoa, ADM, and others);
 - NREL also pioneered the field on biomass pyrolysis and gasification, so called "thermochemical" conversion technologies that compliment the biochemical;
 - NREL is home to user facilities that allow industry to test and evaluate both biochemical and thermochemical technology;
 - From 1978 thru 1996, NREL pioneered the use algae and other aquatic species as a means of producing biofuels.

Cellulosic Ethanol is Right Mission – But Other Needs Must be Addressed

- Though our work laid the building blocks for the successful industry we see today, we could not have foreseen exactly how each potential area of research would play out, and how industry and the marketplace would ultimately respond to it.
- The lesson is that we must continue our resolve to get a cellulosic ethanol industry up and running in the most expeditious way feasible. But at the same time, we should deliberately expand our resolve to encompass additional technologies, systems and fuels; so that industry will have the options it will need to take full advantage of the nation's biofuel potential.

Additional Research We Should Soon Begin

To ensure biofuels can fulfill their full potential for the nation, IN ADDITION to our important work today, we clearly ALSO need to:

- **Sustainability** needs to be addressed through “cradle to grave” research. Recent studies have shown that there is sufficient biomass potential in the U.S., and worldwide, to produce significant amounts of transportation fuels in the displacement of petroleum gasoline and diesel.
 - More understanding is needed about the overall life cycle impacts of biofuel pathways on our environment – our land, water and air.
 - Research on and study of energy crop land use and soil effects must be accomplished. The end-to-end carbon footprint of each pathway must be understood.
- **Physical and chemical properties of biofuels** need to be examined in terms of their impacts on the nation’s fueling infrastructure – materials, storage media, transmission options, and distribution and dispensing operations. These are not insurmountable obstacles -- we have the experts and resources to address these issues. We just need to quickly begin work on these topics, and do so in close collaboration with industry.
- **Thermochemical conversion** should supplement the current ethanol conversion biochemical research, by growing investments and government-industry partnerships. If biochemical conversion is the “elegant” method of producing alcohols from certain biomass feedstocks, then thermochemical conversion is the “sledge hammer, brute force” method of attacking a wider range of feedstocks and producing a broader spectrum of fuels. At high temperatures and pressures, this method reduces biomass to intermediate liquids or gases which can then be synthesized into fuels by numerous proven and emerging technologies. Some of the thermochemical may be able to make better use of existing U.S. infrastructure. We cannot let research in this area lag.
- **Aquatic species** research needs to be re-initiated with federal R&D. NREL’s experts believe that we especially need to explore species that do not require arable land or fresh water, to overcome the limitations of land-based biofuels resources. Aquatic species lend themselves to high yields of lipids that could someday supply the feedstock for the needed quantities of biodiesel, bio-jet fuel, and other high-energy density biofuel products.
 - Aquatic species, algae and other organisms, are capable of producing remarkable levels of lipids and triglycerides – bio-oils – without impacting the food, fiber, and chemical infrastructures of our nation.
 - DOE and NREL conducted a very modest Aquatic Species Program in the past. DOE invested \$24 million dollars over a 17 year period from 1978 to 1996. This work was terminated about the time ethanol research ramped up and the competing product – petroleum diesel – was only \$.60 per gallon.

- Certainly, the focus within DOE clearly needs to remain on cellulosic ethanol for its near term contributions and this near-term objective requires the full commitment of OBP's current budget.
- None-the-less, NREL feels it is time to re-establish a modest amount of research on aquatic species and provide an opportunity for new biofuel options which are not as limited by available amount of arable land and fresh water.
- **Vehicle integration** R&D is required into the performance of biofuels in high efficiency vehicles – to maximize fuel economy and efficiencies while minimizing environmental impact. It is one thing to produce biofuels – it is another to ensure that we have engines and vehicles that can effectively and efficiently utilize them. Research in fuel quality and engine effects, and subsequent fuel testing capability development, must go hand-in-hand with biofuel production and infrastructure development.
- **Other bio-based products and fuel pathways** need to be examined. For example, intermediate biomass products can provide a truly renewable method to produce hydrogen. Along with wind, solar, geothermal, and hydropower electrolysis renewable pathways, bio-derived liquids have the potential to provide significant cost-effective quantities of hydrogen.

What's Needed First? A "National Needs Assessment"

- As a first step to identifying the level of federal activities and investments to meet the President's Advanced Energy Initiative (AEI) and "20 in 10" goals, the Biomass Research and Development Board, created by Congress as part of the Biomass R&D Act of 2000, commissioned the development of the *National Biofuels Action Plan* to identify current biofuels related activities and funding levels in all Federal agencies.
- In parallel, a "National Needs Assessment" is necessary to carefully and realistically assess the resources, workforce, and funding requirements to meet the aggressive national goals for biofuels in the AEI and "20 in 10" Plan.
- The "Needs Assessment" will aide the Biomass R&D Board in their effort to coordinate federal strategic planning and investments in biomass and will aide them in identifying funding gaps or under-funded areas in government.
- The "Needs Assessment" will also provide Congress, State and Federal agencies, the National Bioenergy Center, industry, and academia with objective guidance regarding our current capabilities and resources, coupled with a more accurate accounting of the level of funding required to get this job done.
- Without a practical and thorough "Needs Assessment", it will be difficult if not impossible to accurately plan and budget for this complex mission to meet the President's AEI and 20 in 10.
- Biofuels affects so many aspects of our economy and environment, that this assessment requires an unprecedented level of cooperation between many federal and state agencies, working closely with industry and academia.

- The magnitude of the challenge we face has been likened by some to the Manhattan Project or the Apollo Mission. While these may be similar in technical difficulty; biofuels must achieve a “market price” that has not direct parallel in the previous challenges.

Investment in Biofuels Research Capabilities

- New investments in research capabilities is essential to all other R&D goals. The nation’s world-class laboratory system and its leading academic institutions must be re-tooled, and funded at an adequate level, so we have the necessary capabilities to see this vital mission to its successful conclusion.
- At NREL and the National Bioenergy Center we have begun identifying and establishing the facilities and equipment that it will take for research to meet our national goals, and identifying the improvements that will in turn be required to meet our national needs.

The Fuel and Food Imperative

- We will need to fully study the potential food versus fuel issues, to determine proper policies and incentives in that area to minimize conflicts, meet economical food and fiber requirements and launch an important industry in a positive manner. Our research to date leads us to believe potential conflicts can be avoided, with targeted research, undertaken to inform the best public policies.
- The bottom line is: We need to move quickly toward development of a cellulosic ethanol industry that does not require food commodities. We believe that once that industry is launched, cellulosic ethanol will not compete with corn ethanol, it will evolve with and from it and become a partner technology in the biofuels portfolio.

Workforce Needs

- Beyond the need to invest in research capabilities and facilities, we need a national effort to help focus the resources and attention of universities and other academic institutions onto the area of biofuels research, and renewable energy research generally.
- Even with existing growth in the biofuel industry, we are encountering a dearth of qualified engineers and scientists with the appropriate education and training to make the contributions that are needed in the field. At the same time, a looming shortfall of potential biofuels researchers in the undergraduate system today will only be compounded as industry ramps up its hiring demands in the future. Just as Petroleum Engineering has served this country well as an academic discipline, so too must a new “Biofuels Science and Engineering” discipline become an attractive and fulfilling educational and career path for our emerging workforce.

- NREL's role is to be the national research center – which draws upon regional research and educational capabilities around the country. This is an especially efficient model for biofuels research, as it is expected the biofuels industry will grow up to look different in various regions of the U.S., as each state naturally builds upon its own unique blend of resources and opportunities. A “regionally distributed” research program managed from a national research center will provide benefits.

Developing Uniform Industry Standards

- The issues of fuel quality, engine effects, and fuel testing must be underpinned with a strong, enforceable set of uniform biofuel standards. A recent NREL survey of biodiesel products around the country found the quality to be unpredictable and the range of measurements to be extreme. Even the blending ratios themselves were staggeringly diverse. B20 is intended to be 20% biodiesel and 80% petro-diesel, yet our survey found the range to be from effectively B5 to B 95!
- We must forge the government and industry relationships which will result in a set of standards which assure that the biofuels of the future will work in your car and mine. Fuel testing and fuel quality are important ingredients in the advancement of the biofuels industry.